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Experimental Excitations of Intrinsic Localized Modes in an Air-Levitation-Type Coupled Oscillator Array

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Abstract– An air-levitation-type coupled oscillator chains has been constructed with improving nonlinear springs. The relation of restoring force of the spring to deflection is approximately cubic and symmetrical with respect to the equilibrium in the apparatus with appropriate tensions. It has been observed that, driving one end of the chains sinusoidally with a frequency above the cutoff, localized oscillations can be excited intermittently at the driven end and they are propagated along the chains at a constant speed.

1. Introduction

It is now known that the intrinsic localized modes (ILMs) or the discrete breathers (DBs) are generic in spatially periodic, discrete and nonlinear systems. It is also known that the mobile type of ILMs can be excited both in a spatially infinite system and a semi-infinite system driven at one end sinusoidally at a frequency in a linear stopping band above the passing band (for example [1].)We have shown numerically that ILMs can be excited and propagated in the finite mass-spring chains with the piecewise linear springs driven sinusoidally at one end with the other fixed [2, 3]. The relation between the driving amplitude and frequency to excite ILMs is similar to the one for the ILMs in the case of the FPU-β model unless the amplitude is too large. The results of numerical studies should be used to implement the experiments and we have actually succeeded in experimental demonstrations of ILMs. (The results of the experiments will be published in a forthcoming paper.) We have constructed, improved several mechanical apparatuses of mass-spring chains and take on the experimental studies on ILMs. In this paper, we report manufacturing air-levitation-type chains and the experimental results.

2. Experiments

We have realized the piecewise linear (nonlinear) springs by using and processing barrel-shaped drawn coil springs. In forming a coil spring, previously decided initial tension is provided to spring to change its hardness (i.e. spring constant) to extension. Moreover between two separate positions in the coil, light and non-stretchable strings are stretched to partially suppress elongation of the spring to extension. By these two processing and embedding in the chains with an appropriate tension, each spring could behave nonlinearly to displacements and symmetrically with respect to its quiescent state.

The experimental apparatus we made consists of twenty identical oscillators, nonlinear springs, straight air track (hollow square pipe with many fine air holes) with a blower and driver for forcing the chains at an end. The chains of oscillators connected with neighboring ones through the springs are levitated above the track by pressurized-air shots from holes by the blower, therefore, the oscillators can be moved linearly with less friction.

3. Results

To excite modes of oscillations in the chains, one end of the chains is driven sinusoidally in the direction of the chains at a frequency, whereas the other is fixed. It has been observed that, driving with a frequency above the cutoff, localized oscillations can be excited intermittently at the driven end and they are propagated along the chains at a constant speed. The FFT shows that the peak of the spectrum of the oscillations is located in the region where linear wave propagations are prohibited. Therefore, the localized oscillations can be regarded as the mobile type of ILMs. It has been also shown that, the driving with higher frequency, the interval between excitations of localized oscillations is increased and they are no longer excited when the frequency exceeds a threshold.

Acknowledgments

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